STAB RESISTANT INSERT WITH STEEL CORDS AND NON-WOVEN TEXTILE

Field of the invention.

The present invention relates to a stab-resistant insert for protective textile. The stab-resistant insert comprises at least one metal layer and at least one textile layer. The present invention also relates to a protective textile comprising such a stab-resistant insert.

Background of the invention.

Protective textiles are becoming increasingly important as violence is increasing and is frequently taking forms as attacks on human persons with daggers and theft of luggage with knives in canvasses.

Synthetic fibers such as aramid fibers and high-density high-molecular weight polyethylene fibers have proved to be suitable for bullet-resistance. With respect to stabs such as knives and daggers, however, these fibers only have a poor performance. This is due to the inherent weakness of these synthetic fibers – and of all synthetic fibers - when it comes to transversal resistance.
Metal, and more particular steel, has more resistance to radial compression.

The prior art has already recognized this property of metal and steel.
EP-A2-0 769 671 discloses an anti-stab material with a set of metal strands which are secured to a non-metallic support fabric. The metal strands are uni-directional.
US-A-5,883,018 discloses an optimization of the metal strands for use in anti-stab material. Steel cords with two or more different twisting angles are used to increase the potential to stop penetrating knives.
WO-A1-98/45516 discloses an anti-stab material where steel cords form a lattice, i.e. where both the weft and warp are formed by steel cords.
DE-U1-200 07 820 discloses a combination of anti-stab material and ballistic material. The anti-stab material is formed by a chain mail. Such a chain mail has the advantage of being very flexible, but has the disadvantage of having no form stability. In order to give form stability to the anti-stab material, the chain mail is fixed or bonded at

the edges to a non-woven textile material. In ballistic situations if penetrating bullets break the chains of the chain mail into fragments, the non-woven material catches the fragments in order to prevent these fragments from penetrating into the body.

Conflicting requirements are always put on body armor and protective textile. On the one hand, comfort requirements push the designers towards the use of less material. On the other hand, safety standards increase the amount of impact absorbing and anti-stab materials.

Summary of the invention.

It is an object of the present invention to avoid the drawbacks of the prior art.

It is another object of the present invention to provide for a material which provides both comfort and safety for protective textiles.

It is also an object of the present invention to provide for interaction and synergy between metal and textile.

According to the present invention there is provided a stab-resistant insert for protective textile. The insert comprises at least one metal layer of a fabric with metal cords or metal wires and at least one textile layer.

The textile layer is in contact with and is connected to the metal layer. The textile layer comprises a non-woven material.

The terms "non-woven material" include fibrous structures made by such processes as dry, wet, or air laying, needle-punching, spun-bond processes, and hydro-entanglement. The term non-woven material excludes woven, knitted, and tufted structures. The terms "non-woven fabric" refer to a fabric the fibers of which are either mechanically entangled or chemically bonded to each other.

The use of the non-woven material which is connected to the metal layer leads to a stab resistance.

The metal wires or cords of the metal layer are usually of a plain carbon steel or a stainless steel. In case of carbon steel, the wires and cords are preferably covered with a corrosion-resistant coating such as zinc or a zinc alloy, such as a zinc aluminum alloy.

In the fabric of the metal layer, the metal cords or metal wires may lie in parallel. The distance between two neighboring metal cords or wires varies between 0.40 mm and 3.20 mm, e.g. between 0.50 mm and 3.0 mm.

Next to the advantage of an increased stab-resistance, an additional advantage of contacting and bonding the non-woven textile layer to the metal layer is that the non-woven textile layer prevents the wires or cords in the fabric from unraveling when the metal-textile composite is cut to form a stab-resistant insert.

In a first embodiment of the present invention, the metal wires or cords are unidirectional within one single metal layer, i.e. the elongated metal elements do not cross each other. The metal elements are bonded to the non-woven material by means of an adhesive or by means of a thermoplastic film in order to decrease the likelihood of the elongated metal elements shifting towards each other. In this first embodiment, preferably more than one metal layer is provided. In the various metal layers the elongated metal elements have at least two different directions for the elongated metal elements. When a knife happens to have penetrated a first metal layer, the likelihood of being stopped in a second or subsequent metal layer increases if the second or subsequent metal layer have directions different from the direction in the first layer. Similarly, the likelihood of stopping a knife increases if the number of metal layers increases. However, the number of metal layers is limited by reasons of weight and stiffness. Up to six unidirectional

metal layers are possible. Two, three and four unidirectional layers are preferable.

In a second embodiment of the present invention, at least one metal layer is multi-directional, e.g. bi-directional. This means that within one single metal layer, the elongated metal elements cross each other. This can be realized by welding or by weaving the warp and weft elongated metal elements. Preferably, the warp and weft elongated elements are woven. Preferably the warp and weft elongated elements make a right angle (90 °) with each other. The non-woven material is bonded to the metal layer by means of either an adhesive or by means of a thermoplastic film or by means of stitches. This second embodiment has the drawback of having a metal layer which is somewhat stiffer than a single metal layer out of the first embodiment (unidirectional) but has the advantage that in the final insert, less metal layers are required for a same degree of stab resistance. One or two multi-directional metal layers are preferred. This reduced number of metal layers in the second embodiment may lead to more flexibility or to less weight, compared to the first embodiment.

For both the first and the second embodiment, the inventors have experienced that it is advantageous if the non-woven material comprises some parts, which penetrate between the elongated elements of the metal layer. This penetration may be realized, for example, by needle felting the non-woven material so that the fibers are no longer oriented two-dimensionally alone in the plane of the non-woven material but that some of the fibers are also oriented in a plane perpendicular to the plane of the non-woven material. In this way some of the fibers protrude out of the plane of the non-woven material to penetrate between the elongated elements. This penetration decreases the likelihood that the elongated elements shift towards each other. The presence of the adhesive or of the stitches accentuates this effect.

The non-woven material preferably comprises synthetic fibers. The non-woven material most preferably comprises synthetic fibers which are known to have an impact absorbing effect, such as aramid fibers, para-aramid fibers, high-density high-molecular weight polyethylene fibers, poly(p-phenylene-2,6-benzobisoxazole) fibers (PBO fibers), polybenzimidazole fibers (PBI fibers) or any combination hereof.

In the stab-resistant insert each metal layer may be in contact with and connected with two textile layers, one at each side.

The invention also relates to a protective textile comprising a stab-resistant insert, as described hereabove. The protective textile usually also comprises a bullet-resistant insert. The bullet-resistant insert is normally located close to the body and the stab-resistant insert normally forms the exterior part.

Brief description of the drawings.

The invention will now be described into more detail with reference to the accompanying drawings wherein

- FIGURE 1a is a cross-section of part of a stab-resistant insert according to the invention ;
- FIGURE 1b is an enlarged view of FIGURE 1a ;
- FIGURE 2 shows a first embodiment of the present invention ;
- FIGURE 3 shows a second embodiment of the present invention.

Description of the preferred embodiments of the invention.

FIGURE 1a is a cross-section of part of a stab-resistant insert 10 according to the invention. The stab-resistant insert 10 has a single uni-directional layer of steel cords 12 lying in parallel to each other. The steel cords 12 are of the type 3x3x0.18 in this example. The steel cords 12 form the warp of a woven structure. The weft (not

shown) is formed by a dipped nylon. The weft may also be formed by means of aramide fibers or by means of high-density high-molecular weight polyethylene fibers. The distance between the steel cords is 2.2 mm. Generally, this distance may vary between 0.4 mm and 3.2 mm, e.g. between 0.5 mm and 3.0 mm, whereby the distances are measured as pitches of the cords, i.e. between the axes of the cords. Above the layer of steel cords 12 is a non-woven fabric 14 and under the layer of steel cords 12 is also a non-woven fabric 16. The non-woven fabric is a needle-felt composed with polyacrylate, para-aramid and oxidized polyacrylonitrile fibers. It has a thickness of about 2.30 mm (± 0.30 mm) and a weight of about 80 g/m² (± 8%). Both non-woven fabrics 14 and 16 are bonded to the layers of steel cord 12 by means of a thin thermoplastic film such as polyamide. Adhesives may also be used such as acrylate-based or polyurethane-based adhesives. Due to the needle-felt character of the non-woven fabric, some fibers 19 are directed in a third dimension, i.e. in a plane perpendicular to the plane of the non-woven fabric and penetrate in the openings between the steel cords 12.

FIGURE 2 illustrates a first embodiment of the present invention. The stab-resistant insert has four different parts 10, 20, 30 and 40. Each part 10, 20, 30 and 40 is analogous to the structure of FIGURE 1a and FIGURE 1b, i.e. each part 10, 20, 30 and 40 has resp. a layer of steel cords 12, 22, 32 and 42, which are sandwiched between two non-woven fabrics. The distance between the individual steel cords varies from 0.5 mm to 3.0 mm. The typical form of each part 10, 20, 30 and 40 corresponds to a male back. This typical form has been obtained by means of laser cutting. An additional advantage of using a non-woven fabric according to the present invention is that the non-woven fabrics prevent the steel cords from unraveling, either before or after the laser cutting. In other words the non-woven fabrics favor the integrity of the insert. The presence of an adhesive accentuates this advantage.

An insert as stab-resistant element according to this first embodiment of FIGURE 2 has proved to be successful in combination with a bullet resistant element having a number of layers of high-density high-molecular weight polyethylene fibers (in the market known as DYNEEMA® fibers). The presence of the stab-resistant insert decreases the required number of layers of DYNEEMA® fibers. The reason is that the exterior part is formed by the stab-resistant insert and that this stab-resistant insert may stop already the bullets or at least slows down the bullets.

FIGURE 3 shows a second embodiment of the present invention. The stab-resistant insert 50 comprises a metal layer having steel cords 52 and 53, which cross each other. The metal layer may be formed by a woven structure where both the warp and the weft are steel cords. The distance between the warp steel cords 52 ranges from 0.5 mm and 3.0 mm. The distance between the weft steel cords 54 ranges from 0.5 mm and 3.0 mm. Above the woven metal structure is a non-woven fabric 54 and under the woven metal structure is also a non-woven fabric (not shown). The non-woven fabrics are bonded to the metal layer by means of an adhesive or by means of stitching. The typical form of stab-resistant insert 50 corresponds to a female front. Here again this form has been realized by means of laser-cutting.
This second embodiment has proved to be particularly successful as stab-resistant element in combination with a stack of layers of para-aramid or aramid fibers as bullet-resistant element.

The present invention is not limited to a particular type of elongated metal elements. Metal wires and metal yarns are suitable. However, because of flexibility reasons coupled with safety reasons preference is given to metal multi-strand metal cords with relatively thin filaments, i.e. filaments with a diameter ranging from 0.03 mm to 0.25 mm.
Multi-strand metal cords are usually of the mxn-type, where m is the number of strands and n is the number of filaments within one

strand. Examples of multi-strand cords are :

3x3
7x3
7x4
4x7
3 + 5x7
7x7.

Other cord types or not excluded. These other cord types may be of following general structure :

l + m (+n) : l core filaments, a layer of m filaments and, possibly a layer of n filaments

n x 1 : n filaments twisted together

m + n : m filaments in parallel, surrounded by n filaments twisted around each other and around the m filaments

1 x n CC : compact cord with n filaments all twisted with the same twisting step in the same twisting direction.

The invention is neither limited to a particular type of coating on the metal cords in the metal layer. However, in case the stab-resistant insert is used in a protective textile, which needs to be washed or cleaned, preference is also given to metal cords out of stainless steel or to steel cords being covered with a corrosion-resistant coating such as zinc or a zinc aluminum alloy (from 2% to 9% aluminum). The invention is suitable for all common and available final tensile strengths from 1500 MPa to about 3500 MPa and more